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The Role of Interference and Inhibition Processes
in Dysphoric Early Adolescents

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Abstract

Objective: Cognitive theories emphasize the importance of attentional biases in the development and maintenance of depression. Noteworthy, recent studies indicate that depression-related biases only occur in later stages of attentional processing. This is consistent with the idea that attention is a multi-component process, consisting of at least two mechanisms: selection and inhibition. Therefore, this study aims to investigate interference and inhibition towards angry and happy stimuli in dysphoric adolescents compared to non-dysphoric adolescents.

Method: To examine interference and inhibition of emotional information in 21 dysphoric (17 girls) and 28 non-dysphoric adolescents (17 girls), aged 10 to 16 years, a Negative Affective Priming task was used. In this task, a target has to be evaluated as positive or negative, while ignoring a distractor.

Results: As expected, dysphoric adolescents showed both higher interference from and higher inhibition of angry stimuli relative to non-dysphoric adolescents. In contrast, happy stimuli did not lead to interference and consequently did not have to be inhibited in either group. Finally, a positive relation was found between interference and the subsequent inhibition of emotional stimuli.

Conclusions: These observations confirm the existence of a bias towards angry faces in dysphoric adolescents and also indicate a higher inhibition of angry faces in dysphoric adolescents compared to non-dysphoric adolescents. The obtained results are different from those of similar previous studies in depressed or dysphoric adults using sad faces or negatively valenced words and might reveal important emotion-specific or age-specific inhibitory biases.

Keywords: dysphoria, adolescents, attentional bias, interference, inhibition

The Role of Interference and Inhibition Processes in
Dysphoric Early Adolescents

In general, cognitive theories assign a crucial role to information processing biases in the etiology and persistence of depression (Beck, 1976; Clark, Beck, & Alford, 1999). More specifically, Beck's cognitive model emphasizes the importance of depressogenic self-referent schemas, which operate beyond one's awareness and affect information processing substantially (Beck, 1976). Previous studies on depressed or dysphoric youngsters support the existence of negative biases in different aspects of information processing in this age group, indicating a better memory for negative information (Neshat-Doost, Taghavi, Moradi, Yule, & Dalgleish, 1998; Timbremont, Braet, Bosmans, & Van Vlierberghe, 2008) and an attentional bias for negative, mood-congruent information (Gibb, Benas, Grassia, & McGeary, 2009; Hankin, Gibb, Abela, & Flory, 2010). However, empirical support for the latter finding in depressed individuals is not straightforward. Specifically, results only support depression-related attentional biases under conditions of long stimulus exposure, whereas no attentional bias was found in early "automatic" processes (e.g., Mogg & Bradley, 2005; Neshat-Doost, Taghavi, Moradi, Yule, & Dalgleish, 1997; Peckham, McHugh, & Otto, 2010).

An important variable, which may account for these inconclusive results, is the conceptualization of attention either as a single process or as a set of distinct processes (e.g., Houghton & Tipper, 1994; Neumann & Deschepper, 1992). Depressed individuals might experience particular difficulties disengaging or releasing attention from distracting negative stimuli rather than having problems attending to them and thus only show biases in more elaborative stages of attentional processing (De Raedt & Koster, 2010). Therefore, it is generally assumed that selective attention cannot be viewed as a unitary construct but, rather, a construct that involves at least two underlying processes: active selection of relevant information (e.g., a target stimulus that has to be attended) and inhibition of irrelevant

information (e.g., flankers surrounding the target) (Hasher & Zacks, 1988; Milliken & Tipper, 1998). This dual process of selective attention facilitates responses to relevant to-be-selected stimuli and slows responses to irrelevant stimuli (Gotlib, Yue, & Joormann, 2005; Milliken, Tipper, & Weaver, 1994). During the selection of relevant stimuli, attention can be disrupted by distracting stimuli and therefore requires active inhibition of irrelevant information in order to reduce this interference (Tipper, 1985; Tipper & Cranston, 1985). Moreover, inhibition is responsive to interference, which indicates that the more interference a distractor causes, the more it has to be inhibited (e.g., Goeleven, De Raedt, & Dierckx, 2010; Malley & Strayer, 1995; Milliken et al., 1994). Yet, until now, the effect of emotional distractors on both attentional processes in depressed or dysphoric youngsters remains unclear. Given the crucial role of information processing in the etiology of depression, it is therefore important to study these different attentional components in depth.

Two paradigms that have been extensively used to study attentional processing of emotionally valenced stimuli include the emotional Stroop task and the dot probe task (Mogg & Bradley, 2005; Peckham et al., 2010). Although popular, the abovementioned paradigms only provide a rough measurement of attentional processes since relevant and irrelevant information are presented within the same stimulus presentation (Mogg & Bradley, 2005). It is noteworthy that recent studies in depressed individuals have examined elaborated attentional processing by using more advanced visual attention tasks, such as the exogenous cueing task (e.g., Leyman, De Raedt, Schacht, & Koster, 2007), the affective go/no-go task (e.g., Kyte, Goodyer, & Sahakian, 2005) or the antisaccadic eye movement task (e.g., Hardin, Schroth, Pine, & Ernst, 2007; Sweeney, Strojwas, Mann, & Thase, 1998). Results of these studies offered further evidence for maintained attention for negative information compared to neutral information under conditions of long stimulus exposure (Koster, De Raedt, Goeleven, Franck, & Crombez, 2005; Leyman et al., 2007) and for impaired inhibition of irrelevant stimuli in

depressed adolescents and adults (Hardin et al., 2007; Sweeney et al., 1998). Importantly, however, these paradigms cannot investigate impairments on the level of both selective and inhibitory attentional processes.

To date, only a few studies have used negative affective priming (NAP) tasks that are able to map the process of interference and subsequent inhibition in depressed and dysphoric adults (Goeleven, De Raedt, Baert, & Koster, 2006; Gotlib et al., 2005; Joormann, 2004; Joormann & Gotlib, 2010; Zetsche & Joormann, 2011). In these multi-stimulus tasks, participants are asked to respond to a target stimulus, while ignoring a simultaneously presented emotional distractor stimulus. In the next display, the target may have the same valence as the previous distractor stimulus. Inhibition can be indexed by the degree to which responding to a novel target stimulus is delayed by a previous distractor having the same emotional valence (Wentura, 1999). Results of these studies have yielded mixed results. First, Gotlib et al. (2005) used an adapted version of the NAP task with emotionally valenced words to investigate both affective interference and inhibition. In this task, a target and a distractor were presented simultaneously in each display and participants were asked to name aloud the target word while ignoring the distractor. Results indicated *both a higher interference* from and *a higher inhibition* of negative distractors in dysphoric students. These findings were confirmed in a pictorial NAP study of Zetsche and Joormann (2011), who found that depressive symptoms were associated with a higher inhibition of angry faces. However, other researchers using the NAP task in depressed and dysphoric participants (Goeleven et al., 2006; Joormann, 2004) provided evidence for a *lower inhibition* of sad facial expressions and negative words. Since the focus of these studies was mainly on inhibitory functioning, the level of interference and the association between interference and inhibition of emotional stimuli were not studied (Goeleven et al., 2006; Joormann, 2004; Joormann & Gotlib, 2010). Moreover, until now, studies examining the contribution of each of these two processes in adolescents are, to our knowledge, nonexistent.

Given the limited and mixed results, the aim of the present study was to examine different levels of attentional functioning in dysphoric adolescents. Since it is stated that cognitive biases play a key role in the development of depression (Beck, 1976), it is highly relevant to study different attentional processes in dysphoric or at-risk groups before a full-blown depression occurs. Moreover, adolescents are an interesting subject group since adolescence represents a particularly vulnerable period for the development of depressive symptoms (Dahl, 2004). For instance, dysphoric adolescents face a two-fold to three-fold higher risk of major depression in adulthood relative to adult onset depression (Pine, Cohen, Cohen, & Brook, 1999; Pine, Cohen, Gurley, Brook, & Ma, 1998), with a more severe disease progression (Hankin et al., 1998; Lewinsohn, Rohde, Seeley, Klein, & Gotlib, 2000). Part of this increased vulnerability can be found in ongoing brain development that is characterized by an imbalance between an early maturation of subcortical “affective” regions, such as the amygdala, and a late maturation of prefrontal cortical regions involved in cognitive control processes (Ernst, Pine, & Hardin, 2006).

Against this background, our purpose was to examine interference and inhibition towards negative stimuli in dysphoric youngsters, with the use of a NAP paradigm. Clearly, past research on depression-related attentional biases either has used a broad range of positively and negatively valenced words (e.g., Joormann, 2004; Joormann & Gotlib, 2010; Kyte et al., 2005) or has relied on sad faces (e.g., Goeleven et al., 2006; Joormann, Talbot, & Gotlib, 2007). Based on previous notions that faces are more ecologically valid and stronger than verbal stimuli (Bradley et al., 1997), our research sought to examine attentional processes in response to emotional faces. However, in contrast to previous studies (e.g., Goeleven et al., 2006; Goeleven et al., 2010), we decided not to use sad faces as these stimuli are mood-congruent and familiar to dysphoric youngsters. Instead, we opted for angry faces because these kind of emotional stimuli are thought of bearing direct personal relevance to adolescents suffering from

depressive symptoms and can be associated with the depression-related schemas of social rejection (Gilboa-Schechtman, Ben-Artzi, Jeczemien, Marom, & Hermesh, 2004; Gotlib, Krasnoperova, Yue, & Joormann, 2004; Hames, Hagan, & Joine, 2013). According to interpersonal theories of depression, depressed individuals engage in inappropriate social behaviors that are likely to elicit social rejection, which in turn confirms negative schemas and increases depressive symptoms (Coyne, 1976; Joiner, Alfano, & Metalsky, 1992). Although a bias towards threatening stimuli has often been studied in anxious youth and adults (e.g., Lau & Pine, 2008; Mogg, Bradley, Williams, & Mathews, 1993; Mogg, Philippot, & Bradley, 2004), also a couple of studies in depressed samples have already used angry facial expressions (e.g., Koster, Leyman, De Raedt, & Crombez, 2006; Leyman et al., 2007; Neshat-Doost, Moradi, Taghavi, Yule, & Dalgleish, 2000; Zetsche & Joormann, 2011). Some of these studies provided evidence for an attentional bias towards angry faces in depressed adults (Leyman et al., 2007) and comorbid anxious depressed adolescents (Hankin et al., 2010), whereas others failed to find this bias (e.g., Koster et al., 2006; Neshat-Doost et al., 2000).

Drawing on cognitive theories of depression (Beck, 1976) and the results of studies measuring attentional interference of emotional stimuli in depressed and dysphoric individuals (Gotlib et al., 2005; Hankin et al., 2010; Joormann & Gotlib, 2007; Leyman et al., 2007; Siegle, Ingram, & Matt, 2002), we predict that, relative to healthy controls, dysphoric adolescents will show more interference in the presence of angry compared to happy distractors. With regard to inhibition, based on prior conflicting evidence, two different hypotheses can be proposed. On the one hand, studies using a NAP task with sad faces or negative words in depressed and dysphoric adults (e.g., Goeleven et al., 2006; Joormann, 2004) would suggest a lower inhibition of angry faces in the dysphoric group, i.e. no slowdown or a faster response to negative probe targets in the experimental condition (as compared to the control condition). On the other hand, other studies using similar experimental designs including angry faces or negative words in

dysphoric adults (e.g., Gotlib et al., 2005; Zetsche & Joormann, 2011) would suggest a higher inhibition of angry faces in the dysphoric group, i.e., a slower response to negative probe targets in the experimental condition (compared to the control condition). The latter would be in line with the idea that a higher interference of social rejection stimuli is associated with a higher inhibition of those stimuli in dysphoric youngsters (Milliken et al., 1994; Zetsche & Joormann, 2011).

Method

Participants

Seventy-four Dutch-speaking adolescents between 10 and 16 years of age, including 40 referred adolescents for treatment of emotional problems (28 girls; $M_{\text{age}} = 13.57$, $SD = 1.65$) and 34 non-referred, healthy adolescents (21 girls; $M_{\text{age}} = 12.76$, $SD = 1.28$), participated. In the non-referred group, healthy adolescents were recruited through advertising in schools. In order to have a refined dysphoric and non-dysphoric group, all participants with a score below the subclinical cut-off score on CDI (< 13) in the referred group and those with a score above or equal to this cut-off score (≥ 13) in the non-referred group were excluded from the analyses (Kovacs, 1992). This resulted in a final sample consisting of 21 adolescents with dysphoria (17 girls; $M_{\text{age}} = 12.78$, $SD = 1.23$) and 28 adolescents without dysphoria (17 girls; $M_{\text{age}} = 13.86$, $SD = 1.56$). The research protocol was approved by the Ethics Committee of the University Hospital. Youngsters signed informed assent while legal guardians signed informed consent. After completing the questionnaires and the task, participants were compensated with two cinema tickets.

Measures

Depressive symptoms. A Dutch version of the Children's Depression Inventory (CDI; Kovacs, 1992; Dutch version by Timbremont & Braet, 2002) was used to assess depressive

symptoms. The CDI is a self-report questionnaire derived from the Beck Depression Inventory (BDI; Beck, Ward, Mendelsohn, Mock, & Erbaugh, 1961) and is used in children and adolescents aged 7 to 17 years. It consists of 27 items, which assesses cognitive, affective, and behavioral symptoms of depression. Each item has three response options, which vary in severity (e.g., “I do most things wrong”, “I do many things wrong”, “I do everything wrong”). Adolescents are asked to select the statement that best describes how they have been feeling during the past two weeks. A total depression score consists of the sum of all individual items. CDI showed good psychometric qualities in terms of internal consistency and test-retest reliability in non-clinical samples (Craighead, Smucker, Craighead, & Ilardi, 1998; Timbremont & Braet, 2002). Cronbach’s alpha on the CDI in this sample was $\alpha = .90$.

General psychopathology. The Child Behavior Checklist (CBCL) is a parent-report questionnaire measuring emotional and behavioral problems in children and adolescent aged 6 to 18 years (Achenbach & Rescorla, 2001; Dutch version by Verhulst, Ende, & Koot, 1996). It consists of 113 items, which are scored on a three-point scale and represent 8 syndromes of psychopathology. The scores on these syndrome scales can be summed up to calculate a dimensional score for internalizing problems, externalizing problems, and total problems. Additionally, DSM-oriented scales can be computed measuring Affective Problems, Anxiety Problems, Somatic Problems, Attention-Deficit/Hyperactivity Problems, Oppositional Problems, and Conduct Problems. These scales appear to be a valid and reliable screening measure for DSM-IV disorders (Achenbach & Rescorla, 2001; Nakamura, Ebesutani, Bernstein, & Chorpita, 2009). In this study, the CBCL Total Problem scale and the DSM-oriented scale for ‘Anxiety Problems’ were used. Internal consistency for the CBCL Total Problems scale and the CBCL Anxiety subscale was good with a Cronbach’s alpha of .97 and .71, respectively.

Experimental Task

Inhibitory control. A Negative Affective Priming (NAP) task was used to measure the adolescents' capacity to selectively attend to stimuli while ignoring distracting emotional information. In order to explore the interference and the subsequent inhibition of irrelevant emotional distractors, each trial included a pair of prime and probe displays (Joormann, 2004). It is noteworthy that participants cannot notice any differences between these displays since both prime and probe displays consist of a distractor (e.g., picture with grey frame) and a target (e.g., picture with black frame). On each display, participants are instructed to evaluate the target as positive or negative, while ignoring (inhibiting) the distractor.

Since *interference* occurs during the selection process and is generally measured in tasks in which participants are asked to respond to a target stimulus in the presence of a distractor stimulus (Goeleven et al., 2010), the prime displays are used to target this process. The control condition, in which the target and the simultaneously presented distractor stimulus share the same valence, is compared to the experimental condition, in which the valence between target and distractor is different. If attention is interfered by the simultaneous presence of an incongruent emotional distractor, responding to the target in the experimental condition will be delayed and reaction times will be slower compared to the control condition.

To measure the *inhibition* of irrelevant emotional stimuli, both prime and probe displays are taken into account. Specifically, the correspondence between the distractor in the prime display and the target in the subsequent probe display has to be considered. In the experimental condition, the valence of the distractor in the prime display is similar to the valence of the target in the probe display. Experimental trials are compared to control trials in which there is no such similarity between prime distractor and probe target. If the inhibition of (the valence) of the prime distractor is still activated, responses to a probe target of the same valence will be delayed in the experimental condition. Thus, the more inhibition of an emotionally valenced distractor, the longer the response time in the experimental condition compared to the control condition

(Joormann & Gotlib, 2010). Importantly, to exclude interference effects on probe displays, the distractor is always a neutral face. Table 1 gives an overview of the NAP task design.

-----Table 1 about here please-----

The NAP task was programmed using the INQUISIT Millisecond software package and was run on a laptop with a 72-Hz, 17-inch color monitor (Goeleven et al., 2006). The pictorial stimuli were selected from two validated databases: a recently developed database of child face images (Verfaillie, Theuwis, & Wante, 2012) and the 10 child faces of the Radboud Faces Database (Langner et al., 2010). The final stimulus set included neutral faces ($n = 22$), positive faces (happy; $n = 33$), and negative faces (angry; $n = 33$). The pictures were set at 180 x 200 pixels and a black or grey colored frame was added to indicate if they were a distractor or a target. To exclude ‘feature based’ negative priming effects, eight separate lists of 11 randomly chosen pictures sharing the same valence were used: one angry and one happy prime target list, one angry and one happy prime distractor list, one angry and one happy probe target list and two neutral probe distractor lists.

Participants were told that two pictures of different child faces would appear in the top and bottom half of the screen. They were asked to evaluate the emotional valence of the target picture -indicated by a specific color of the frame (either black or grey)- as accurately as possible by pressing the corresponding key on the response box (green button or blue button) using the index finger of each hand. In addition, they had to ignore the distractor stimulus. The precise sequence of one complete NAP trial is as follows: first, a fixation cross was presented for 1000 ms. After the disappearance of the fixation cross, the prime display consisting of a distractor picture and a target picture was presented on the screen until the participants responded. There were two possible scenarios: either the prime distractor and the prime target

shared the same valence (control condition) or the valence of the prime distractor was different from the prime target (experimental condition). Following the response on the prime display, a blank screen was shown for 1000 ms. Then, another fixation cross was shown and after 1000 ms the probe display started (see Figure 1). Again, two pictures of child faces were presented and the participants were asked to respond to the target picture indicated by a grey or a black frame, while ignoring the distractor. Here, the probe-target either had the same valence as the prime-distractor (experimental condition) or was different from the prime-distractor (control condition). Both the response cue (black or grey frame) and the key assignment were counterbalanced between the participants. Moreover, the sequence of congruent and incongruent prime-probe displays and the spatial position of the target and the distractor were randomly assigned from display to display, with an equal number of presentations for each condition.

-----Figure 1 about here please-----

Procedure

All participants were invited to the lab at the Faculty of Psychology and Educational Sciences. After signing assent/consent, participants were seated in front of a computer and task instructions were displayed on the computer screen. To ensure clarity of the instructions, these were also repeated orally by the experimenter. Before starting with the experiment proper, participants completed 32 practice trials and were able to ask for help if needed. Next, the adolescents were instructed to complete the test phase consisting of 256 trials randomly assigned to 8 blocks of 32 trials (prime + probe display). After finishing the NAP task, all participants filled out the Children's Depression Inventory (CDI) questionnaire. This order of testing prevents priming effects caused by self-report questionnaires and ensures that the CDI-

questionnaire does not tire or overwhelm participants before starting the NAP task. One of the parents completed the CBCL while waiting for their child to finish the task (Achenbach & Rescorla, 2001; Dutch version by Verhulst et al., 1996).

Only responses that were correct in both prime and probe displays were used for the data analysis. Consistent with previous NAP studies in adults (Goeleven et al., 2006; Joormann, 2004), extreme reaction times (below 300 ms and above 2000 ms) were considered outliers (anticipated and delayed responses) and were excluded from the analyses. The interference scores were calculated by subtracting the reaction times in the control condition from the reaction times on the experimental condition *in the prime displays*. Also inhibition scores were computed by subtracting reaction times in the control condition from reaction times in the experimental condition *in the probe displays*. An interference and inhibition score for positive and negative stimuli was calculated separately for each adolescent.

Data Analyses

Given that results of a Shapiro-Wilk test indicated that all NAP indices were not normally distributed (all $ps < .05$), a log 10 transformation was used to normalize the distribution of the NAP data. In order to investigate interference and inhibition effects in the two distinct groups, a 2 x 2 x 2 (Priming Condition [control, experimental] x Picture Valence [negative, positive] x Group [dysphoric, non-dysphoric]) repeated-measures ANOVA was conducted. The ANOVA was run twice, once for the interference effect (with response times on the targets of the prime displays as dependent variables) and once for the inhibition effect (with response times on the targets of the probe displays as dependent variables). Furthermore, Pearson correlation coefficients were computed between interference and inhibition scores for positive and negative stimuli to examine the association between inhibition and interference across all participants

and separately for each group. Fisher's r -to- Z transformation was used to compare the correlation coefficients of the dysphoric and the non-dysphoric group.

Because of the continuous development of executive functioning during adolescence (Diamond, 2002), we reran the analyses with age as a covariate of no interest. In addition, since dysphoria and anxiety are frequently associated with one another (AACAP, 2007) and to rule out a potential contributing factor, anxiety was also added as a covariate of no interest. Next, given that the dysphoric group was referred for treatment, there may be other co-occurring symptoms besides anxiety that could influence interference and inhibition processes in this group. Therefore, the overall level of symptoms on the CBCL Total Problems scale was included in the analyses. Further, the impact of gender was explored by also adding this as a covariate of no interest to the repeated measure analyses. Importantly, all abovementioned covariates were entered simultaneously in one model. Finally, to assess the contribution of symptom severity, correlation analyses were performed between CDI scores and the different performance variables. Effects sizes are provided as partial eta squared (η_p^2) and Cohen's d , as appropriate. Alpha was set a $p = 0.05$, two-tailed. Mean RTs and SDs as a function of group are shown in Table 2.

-----Table 2 about here please-----

Results

Group characteristics

As expected, groups differed on depressive symptoms, as measured with the CDI, $F(1, 48) = 105.91, p < .001, \eta_p^2 = .69$, with a significantly higher score in the dysphoric group (range, 13-35) compared to the non-dysphoric group (range, 1-12). Furthermore, one-way ANOVAs indicated significant group differences on CBCL Anxiety symptoms, $F(1, 48) = 28.03, p < .001$,

$\eta_p^2 = .37$, and CBCL Total problem scores, $F(1, 47) = 102.84$, $p < .001$, $\eta_p^2 = .69$. The CBCL DSM-oriented scales indicated that 76% of the dysphoric adolescents met criteria for affective problems. Noteworthy, 66% of the dysphoric group experienced comorbid affective and other psychological problems, such as anxiety problems (14%), somatic problems (9%), or a combination of these two (14%). In the control group, none of the participants met criteria for psychological problems. The gender distribution did not significantly differ between the two groups, $\chi^2(1, 49) = 2.31$, $p = .128$, but a significant difference on age, $F(1, 48) = 7.25$, $p = .01$, $\eta_p^2 = .13$ emerged (Table 3).

-----Table 3 about here please-----

Interference Effects

As predicted, the crucial three-way interaction among priming, valence, and group was significant, $F(1, 47) = 16.50$, $p < .001$, $\eta_p^2 = .26$. Results revealed that the interference score for angry stimuli (with angry distractors and happy targets) was significantly higher in the dysphoric group ($M = 110.19$ ms, $SD = 18.97$ ms) than in the non-dysphoric group ($M = 44.78$ ms, $SD = 78.88$ ms), $t(31) = -4.23$, $p < .001$, Cohen's $d = -1.14$ (Figure 2A).

Moreover, results showed that the interference scores for happy stimuli were significantly lower ($M = -41.28$ ms, $SD = 49.61$ ms) in the dysphoric group compared to the control group ($M = 1.53$ ms, $SD = 77.94$), $t(47) = 2.04$, $p = .047$, Cohen's $d = -.66$. Specifically, based on one sample t-tests on the interference scores, there was no interference from happy stimuli (with happy distractors and angry targets) in the control group, $t(27) = -.10$, $p = .918$, and a facilitation rather than interference from happy stimuli in the dysphoric group, $t(20) = -3.81$, $p = .001$.

Inhibition Effects

Similar to the interference effects, the same three-way interaction among priming, valence, and group was significant in the inhibition analysis, $F(1, 47) = 16.64, p < .001, \eta_p^2 = .26$. Independent t -tests revealed that the inhibition score for angry stimuli was significantly higher in the dysphoric group ($M = 104.23, SD = 21.76$) relative to the control group ($M = 21.25, SD = 86.77$), $t(31) = -4.86, p < .001$, Cohen's $d = -1.31$ (Figure 2B). Moreover, results of independent sample t -tests indicated no significant differences regarding inhibition of happy stimuli between both groups, $t(47) = 1.49, p = .143$.

-----Figure 2A and 2B about here please-----

Relation between Interference and Inhibition

The results of Pearson correlations across all subjects showed a significant positive association between interference scores and inhibition scores for angry stimuli, $r(47) = .55, p < .001$, and a marginally significant positive correlation between interference scores and inhibition scores for happy stimuli, $r(47) = .28, p = .054$. When differentiating between the two groups, the results indicate a significant positive correlation between interference and inhibition of angry stimuli in both the dysphoric, $r(19) = .80, p < .001$, and the non-dysphoric group, $r(26) = .38, p = .045$. Furthermore, we found a significant association between interference and inhibition of happy stimuli in the dysphoric group, $r(19) = .95, p < .001$, but not in the non-dysphoric group, $r(26) = -.03, p = .892$. The results of subgroup analyses revealed that correlations between interference and inhibition are significantly stronger in the dysphoric group compared to the non-dysphoric group, both for angry ($Z = 2.26, p = .024$) and happy stimuli ($Z = 5.83; p < .001$).

Additional Analyses of Age, Comorbid Anxiety, Gender, Total Problems, and Symptom Severity

All analyses were rerun to examine the impact of age, comorbid anxiety, gender, and total problems on the interference and inhibition effects. Results indicated that the three-way interaction among priming, valence, and group remained significant in the interference analysis, $F(1, 41) = 6.76, p = .01, \eta_p^2 = .14$, and in the inhibition analysis, $F(1, 41) = 4.15, p = .048, \eta_p^2 = .092$. Moreover, none of the covariates were significant predictors of interference or inhibition (all $ps > .05$). Furthermore, CDI scores were not significantly correlated with the different performance variables (all $ps > .05$, Bonferroni corrected for multiple comparisons).

Discussion

The primary goal of this study was to assess interference and inhibitory processes in dysphoric adolescents by adopting the NAP paradigm. As hypothesized, the results confirmed that dysphoric adolescents experience greater interference from angry facial expressions compared to non-dysphoric adolescents. Furthermore, dysphoric adolescents showed greater inhibition of previously presented angry distractors in comparison to the non-dysphoric group, who did not inhibit distracting angry faces. A noteworthy result is that for both groups positively valenced distractors did not lead to interference and consequently did not have to be inhibited. Moreover, the findings revealed a relationship between interference and the subsequent inhibition of an emotionally valenced stimulus. Apparently, the inhibition effect is dependent on the degree of interference caused by different emotional stimuli in our sample, which is consistent with the results of earlier studies (Goeleven et al., 2010; Gotlib et al., 2005). A closer look to the correlations within the groups revealed that the correlation between interference and inhibition effects was significantly greater in the dysphoric group compared to the non-

dysphoric group. The low correlation in the non-dysphoric group can be explained by the small variance in the interference and inhibition scores of angry and happy stimuli.

In general, the results of this study provide empirical support for the presence of an attentional bias for angry faces in dysphoric youngsters. Specifically, dysphoric adolescents demonstrated greater interference compared to non-dysphoric adolescents, as reflected by greater performance impairment by the simultaneous presentation of an angry distractor. This is in line with previous research on depressed and at-risk youngsters for whom there exist attentional biases for negative information under conditions of long stimulus exposure (e.g., Hankin et al., 2010; Hommer et al., 2014; Joormann & Gotlib, 2007). Regarding stimulus-specificity, it is worth pointing out that, in contrast to the majority of previous studies that investigated attentional biases towards sad stimuli (e.g., Joormann & Gotlib, 2007; Joormann et al., 2007), the current study used angry faces to represent negative (social) information. Interestingly, a previous study of Hankin et al. (2010) with angry and sad stimuli, only provided evidence for an attentional bias towards angry faces in comorbid depressed anxious adolescents, while the pure depressed group only showed an attentional bias towards sad faces. However, this study differs on two important aspects with respect to our study. First, the study measured attentional functioning using a dot probe task. Since this task does not allow the distinguishing between different attentional processes, results cannot be directly compared with the present study. Second, while Hankin et al. (2010) included adolescents diagnosed with a major depressive disorder, the current study focused on dysphoric adolescents who are referred for emotional problems for the first time, prior to any diagnosis and who are also medically naive.

With regard to the effect of positive stimuli, results indicated that interference from happy distractor faces was significantly lower in the dysphoric group compared to the non-dysphoric group. More concretely, relative to controls, dysphoric youngsters were significantly faster in prime displays with a happy distractor (experimental condition; different valence as

the target) relative to prime displays with an angry distractor (control condition, same valence as the target). This suggests that happy faces facilitate their response to the target stimulus. A potential explanation for this result is that dysphoric adolescents have the tendency to direct their attention away from positive social information (schema-incongruent) and therefore show a faster response time to the target stimulus in the presence of a happy distractor (Leppanen, 2006). This is in contrast to angry distractors (schema-congruent), which capture their attention and reduce the capacity to selectively attend to the relevant target picture. Moreover, these results provide additional evidence for differences in processing happy versus angry stimuli in dysphoric adolescents (Gotlib, Kasch, et al., 2004; Gotlib, McLachlan, & Katz, 1988).

On the level of inhibitory processes, a pronounced inhibition of angry stimuli was observed in dysphoric individuals compared to non-dysphoric ones. That is, dysphoric participants responded slower to angry probe targets if the previous prime distractor had the same valence. These findings indicate that dysphoric adolescents were more easily distracted by angry faces and subsequently inhibit them more. This corresponds to the results of previous studies indicating a higher inhibition of angry faces (Zetsche & Joormann, 2011) and negatively valenced words (Gotlib et al., 2005) in students suffering from depressive symptoms.

However, the current findings are inconsistent with those found in several similar NAP studies, which indicated less inhibition of negative stimuli in depressed adults (Goeleven et al., 2006; Joormann, 2004). First, the discrepancy may be associated with stimulus-specific differences. For instance, despite using the same pictorial task design, previous studies included sad faces, while the current study relied on angry faces as negative emotional information. Since angry faces might activate depression-related schemas of social rejection and therewith increase negative affect, these stimuli might be highly interfering and evoke strong inhibitory responses (Gilboa-Schechtman et al., 2004; Hames et al., 2013). This contrasts with sad faces, which are congruent with a depressed mood state and therefore are considered to be less salient or

distracting to dysphoric individuals. This is consistent with the NAP study of Zetsche and Joormann (2011), which included both sad and angry faces and showed a lower inhibition of sad stimuli and a higher inhibition of angry stimuli in students with depressive symptoms. Furthermore, when considering NAP studies investigating inhibitory processes using verbal stimuli, evidence is found for both a higher and a lower inhibition of negative stimuli (Gotlib et al., 2005; Joormann, 2004). Since negative verbal stimuli might be associated with a broad range of negative emotions (e.g., sadness, fear, disgust, anger, ...), it is not clear to which extent the nature of inhibitory dysfunction is stimulus-specific in these findings. Second, the different results may also be explained by developmental differences between adolescent and adult samples. Although previous studies have shown a lower inhibition of negative stimuli in depressed adults (e.g., Goeleven et al., 2006; Joormann & Gotlib, 2010), this study indicates a higher inhibition of angry faces in dysphoric adolescents. This might point to a higher cognitive investment to deal with the attentional disturbance from angry stimuli in dysphoric youngsters compared to depressed adults. This is in line with past research findings, which suggest a negative association between longitudinal depression severity and executive functioning in adults (Harvey et al., 2004). However, caution is warranted in drawing conclusions since this study differs from other NAP studies both in terms of developmental level and stimulus characteristics. Moreover, including age as a covariate in our analyses did not change the reported results. It is clear that more research in medication-free adolescents using mental health services for the first time is needed to fully understand the differences with previous studies.

Our findings are further inconsistent with a recent meta-analysis of cognitive functions in depressed children and adolescents, which reported consistent deficits in inhibitory capacity (Wagner, Muller, Helmreich, Huss, & Tadic, 2015). However, the meta-analysis of Wagner et al. (2015) relied on non-emotional Stroop tasks for investigating inhibitory functioning in depressed youth. Therefore, the explanation for the incongruence may lie in the different nature

of the tasks involved. Specifically, in contrast to the NAP task, the Stroop task does not allow to present more than one stimulus at a time, which makes it impossible to map different aspects of attention (Koster, Crombez, Verschuere, & De Houwer, 2004). Consequently, findings from Stroop and NAP tasks might be influenced by different underlying processes, making it impossible to compare them with one another. In addition, while the current study has focused on emotional interference on cognitive functioning, the meta-analysis of Wagner et al. (2015) included studies using neutral stimuli and thus only provided evidence for a general cognitive impairment in depressed youth.

From a clinical viewpoint, we assume that malfunctioning attentional processing of angry stimuli might be related to emotion regulation difficulties. Specifically, dysphoric adolescents showed a heightened interference of angry distractors during cognitive processing, indicating problems with the bottom-up filtering of emotional information. Consequently, the increased negative affect and the emotional lability that characterizes dysphoric adolescents may be related to problems in this attentional process. Moreover, we hypothesize that the heightened interference and subsequent inhibition of negative (social) information draw largely on cognitive resources and reduce cognitive capacity, thereby leading to difficulties regulating negative emotions. In this context, an interesting avenue for future research is to investigate further the impact of different attentional processes on emotions in early adolescent samples and to explore how these negative attentional biases would shift after participating in an emotion regulation training. On this topic, promising results in depressed adults have already been discussed in the review by Joormann and Vanderlind (2014). Moreover, identifying the precise early underlying cognitive processes in dysphoric adolescents is highly important as it may also stimulate the development of age-appropriate preventive treatment strategies that reduce the impact of subclinical depressive symptoms before a chronic course emerges (Pine et al., 1999).

The main strength of the study lies in its focus on several aspects of attentional functioning in a sample consisting of dysphoric adolescents. Since adolescence proves a critical period of vulnerability to depression and given the elevated risk of a depressive disorder in adulthood following first-onset depression in adolescence (Fombonne, Wostear, Cooper, Harrington, & Rutter, 2001), research on the underlying mechanisms in this age group is undoubtedly needed. Moreover, while previous studies in depressed adults are limited by depression severity and recurrent episodes, studying dysphoric adolescents who are referred for the first time, enables us to have a clearer look at the baseline cognitive processes.

Furthermore, in contrast to many other studies of attentional biases using emotional words as stimuli (e.g., Joormann, 2004; Joormann & Gotlib, 2010), the NAP task adopted in this study included pictures of child faces in order to provide higher ecological validity. We specifically focused on angry faces since these stimuli are presumed to represent relevant social stimuli for the participants, given the profound interpersonal difficulties and social rejection depressed individuals experience (Hames et al., 2013). Additionally, the use of a pictorial NAP task, consisting of prime and probe displays, enabled us to explore attentional functioning in great depth because the subprocesses of stimulus selection and subsequent inhibition could be differentiated.

However, in interpreting the results of this study, several limitations should be acknowledged. First, we assessed depressive symptoms through a self-report questionnaire (CDI; Kovacs, 1992; Dutch version by Timbremont & Braet, 2002). Although the CDI is a reliable depression screening instrument, the use of a structured clinical interview is required to diagnose the presence of a major depressive disorder (Hien et al., 1998). Even though all the clinical participants in our study were referred for emotional problems, replication of these results is needed with a sample of diagnosed depressed adolescents.

Another limitation is that we used parent-reports of child anxiety. Since adolescents are a better reporter of their internalizing problems compared to their parents (Achenbach, McConaughy, & Howell, 1987), the effects of anxiety might have been lessened as a result of the source of information. However, the results of a study conducted by Bodden, Bogels, and Muris (2009), who investigated the diagnostic utility of a specific screening tool for identifying anxiety disorders in youngsters (8-18 years old), indicated that parent report of anxiety had highest sensitivity and specificity compared to self-report and could be seen as the most reliable way to screen for anxiety problems in children and adolescents. Moreover, including anxiety symptoms in the analyses as a covariate of no interest did not alter the main findings.

In contrast to most previous studies that focused on sad stimuli (e.g., Goeleven et al., 2006; Joormann et al., 2007), the current study examined depression-related processing biases in relation to angry facial expressions. Since sad faces were not included in our stimulus set, we could not compare the effects of different types of negative stimuli on interference and inhibition processes. Therefore, the present results do not allow us to determine whether the observed effects are stimulus-specific or relate to negative emotional stimuli in general.

Finally, it will be interesting to replicate this study on adolescents at the risk of depression and previously depressed adolescents in order to explore if attentional biases play a role in the development or recurrence of depression and not merely represent a symptom of depressed mood. In fact, if future research continues to demonstrate the important role of maladaptive attentional processes in the etiology and maintenance of depression in youngsters, current prevention programs will have to take account of specific cognitive risk factors and make improvements accordingly (Siegle, Ghinassi, & Thase, 2007).

Conclusion

The results of the current study provide new insights regarding attentional processing in dysphoric adolescents. Specifically, the findings show that dysphoric adolescents show higher interference from and higher inhibition of angry faces relative to non-dysphoric adolescents. Importantly, this finding contrasts with previous NAP studies in depressed and dysphoric adults indicating less inhibition of sad faces or negatively valenced words. Therefore, we may assume that depression-related inhibitory processes are stimulus-specific. While angry faces activate schemas of social rejection and therefore evoke a strong inhibitory response, sad faces are mood-congruent and are considered to be less threatening for depressed or dysphoric individuals. Furthermore, the inconsistency with previous research might also reflect developmental differences between adolescent and adults samples in depressogenic information processing. However, since our study differs with other NAP studies both in terms of developmental level and stimulus characteristics, more research is needed to clearly understand the observed differences. It will be important for future studies to more closely investigate the impact of both sad and angry stimuli on different components of attentional functioning in depressed and dysphoric individuals. Moreover, longitudinal studies are needed to assess interference and inhibition processes in at risk-youngsters and adolescents diagnosed with depression to explore the role of attentional processes in the development and maintenance of depression.

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Table 1

Control and Experimental Condition for Negative and Positive Trials in a NAP task

		Negative trials		Positive trials	
		Control condition	Experimental condition	Control condition	Experimental condition
Prime display	Distractor	+	-	-	+
	Target	+	+	-	-
Probe display	Distractor	N	N	N	N
	Target	-	-	+	+

Note. Negative trials measure the effect of negative stimuli; positive trials measure the effect of positive stimuli. Prime displays are used to index interference; the correspondence between prime distractor and probe target is crucial to measure inhibition.

+ positive picture, - negative picture, N neutral picture

Table 2

Mean response times and standard deviations (in ms) for the negative affective priming condition as a function of group

		Dysphoric		Non-dysphoric	
		Experimental	Control	Experimental	Control
Prime displays					
	Negative trials	1092 (33)	982 (32)	1056 (104)	1011 (106)
	Positive trials	962 (28)	1004 (62)	1069 (143)	1071 (129)
Probe displays					
	Negative trials	1090 (32)	985 (34)	1035 (131)	1013 (115)
	Positive trials	960 (32)	1003 (63)	995 (121)	1010 (121)

Note. Standard deviations are shown in parentheses.

Table 3

Characteristics of the Study Sample

	Dysphoric	Non-dysphoric
<i>N</i>	21	28
Sex (female/male)	17/4	17/11
Age*	13.86 (1.56)	12.78 (1.23)
Depression***	18.90 (5.86)	5.57 (3.11)
Anxiety***	4.47 (2.80)	1.25 (1.14)
Total problem score***	69.57 (23.58)	18.37 (10.24)

Note. Standard deviations are shown in parentheses. * $p < .05$; ** $p < .01$; *** $p < .001$

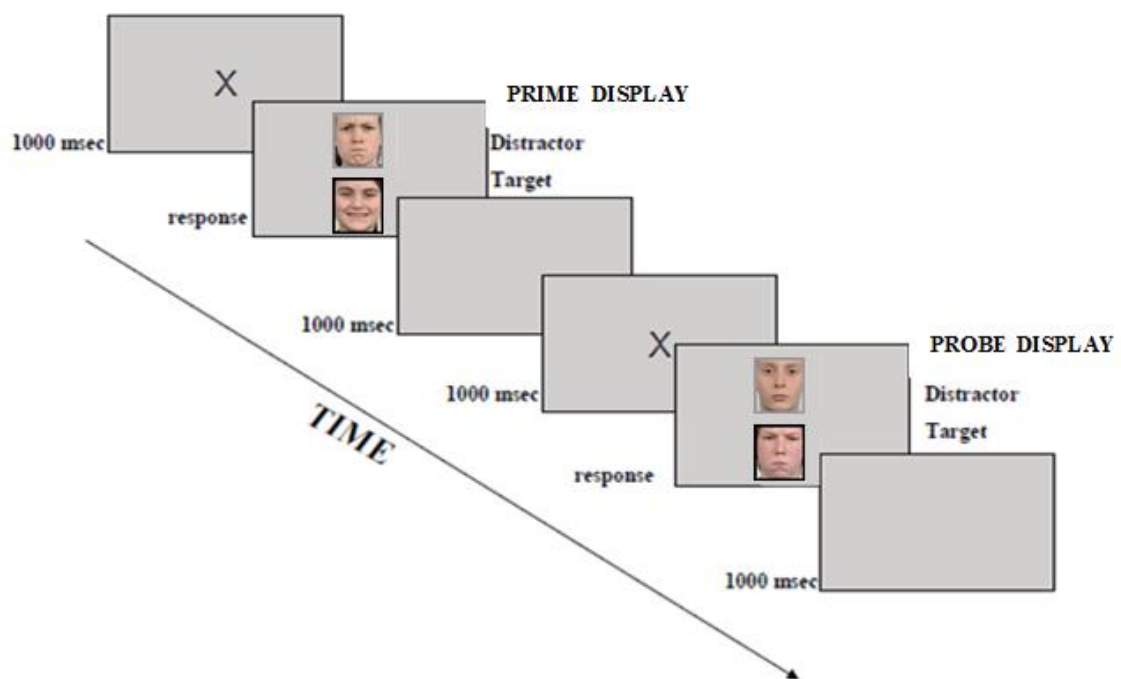


Figure 1. Example of a complete NAP trial: prime and probe displays (experimental condition). Prime and probe displays include a distractor and a target and are always preceded by a fixation cross.

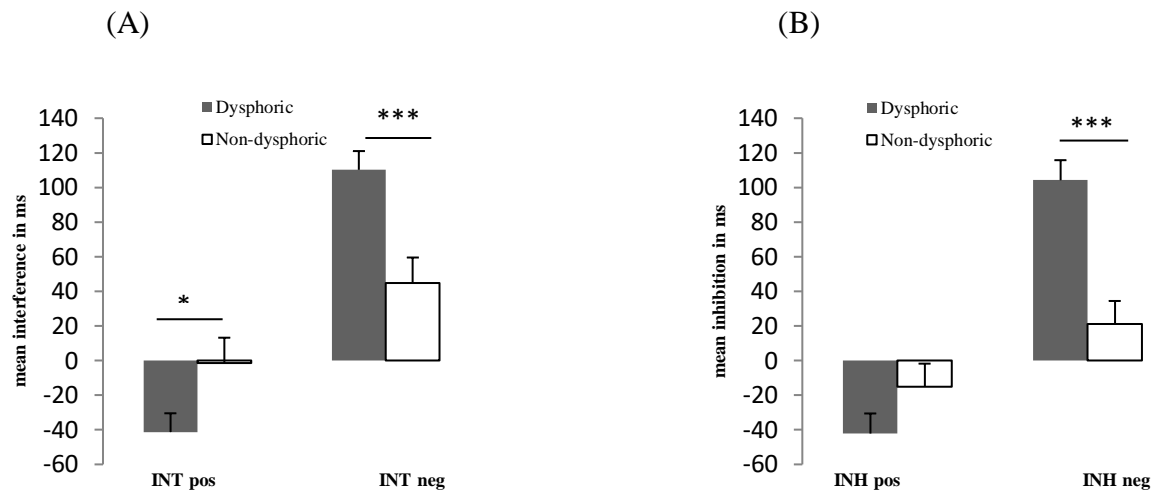


Figure 2. (A) Mean interference scores (experimental – control; prime displays) and standard error of the mean for positive and negative trials as a function of group. (B) Mean inhibition scores (experimental – control; probe displays) and standard error of the mean for positive and negative trials as a function of group. * $p < .05$; ** $p < .01$; *** $p < .001$